UNITED STATES MARINE CORPS
Logistics Operations School
Marine Corps Combat Service Support Schools
Training Command
PSC Box 20041
Camp Lejeune, North Carolina 28542-0041

AIM 5203

STUDENT HANDOUT

REPAIR POWER STEERING SYSTEM COMPONENTS

LEARNING OBJECTIVES:

1. Terminal Learning Objectives:

a. Given a hydraulic power cylinder assembly that is featured in the M939 Series vehicle steering system, the required tools, shop supplies, repair parts, and TM 9-2320-272-34-2, per information contained in the reference, repair the power cylinder. (5.2.1)

b. Given a Model HFB-64 steering gear assembly, the required tools, shop supplies, repair parts, and TM 9-2320-272-34-2, per information contained in the reference, repair the steering gear assembly. (5.2.2)

c. Given a steering gear assembly used in the MK48 steering system, the required tools, shop supplies, repair parts, and TM 9-2320-297-34, per information contained in the reference, repair the steering gear. (5.2.3)

d. Given a yaw control valve used in the MK48 steering system, the required tools, shop supplies, repair parts, and TM 9-2320-297-34, per information contained in the reference, repair the yaw control valve. (5.2.4)

e. Given a yaw cylinder used in the MK48 steering system, the required tools, shop supplies, repair parts, and TM 9-2320-297-34, per information contained in the reference, repair the yaw cylinder. (5.2.5)

f. Given a tandem hydraulic pump used in the MK48 steering system, the required tools, shop supplies, repair parts, and TM

9-2320-297-34, per information contained in the reference, repair the tandem hydraulic pump. (5.2.6)

2. Enabling Learning Objectives:

a. Given a hydraulic power cylinder assembly that is featured in the M939 Series vehicle, the required tools, shop supplies, repair parts, and TM 9-2320-272-34-2, per information contained in the reference:

(1) disassemble the power cylinder assembly, (5.2.1a)

(2) inspect the disassembled components for serviceability, (5.2.1b)

(3) repair or replace the unserviceable components, (5.2.1c)

(4) assemble the power cylinder assembly from serviceable components. (5.2.1d)

b. Given a Model HFB-64 steering gear assembly, the required tools, shop supplies, repair parts, and TM 9-2320-272-34-2, per information contained in the reference:

(1) disassemble the steering gear assembly, (5.2.2a)

(2) inspect the disassembled components for serviceability, and (5.2.2b)

(3) repair or replace the unserviceable components, and (5.2.2c)

(4) assemble the steering gear assembly from serviceable components. (5.2.2d)

c. Given a steering gear assembly used in the MK48 steering system, the required tools, shop supplies, repair parts, and TM 9-2320-297-34, per information contained in the reference:

(1) disassemble the steering gear assembly, (5.2.3a)

(2) inspect the disassembled components for serviceability, (5.2.3b)

(3) repair or replace the unserviceable components, and (5.2.3c)

(4) assemble the steering gear assembly from serviceable components. (5.2.3d)

d. Given a yaw control valve used in the MK48 steering system, the required tools, shop supplies, repair parts, and TM 9-2320-297-34, per information contained in the reference:

(1) disassemble the yaw control valve, (5.2.4a)

(2) inspect the disassembled components for serviceability, (5.2.4b)

(3) repair or replace the unserviceable components, and (5.2.4c)

(4) assemble the yaw control valve from serviceable components. (5.2.4d)

e. Given a yaw cylinder used in the MK48 steering system, the required tools, shop supplies, repair parts, and TM 9-2320-297-34, per information contained in the reference:

(1) disassemble the yaw cylinder, (5.2.5a)

(2) inspect the disassembled components for serviceability, (5.2.5b)

(3) repair or replace the unserviceable components, and (5.2.5c)

(4) assemble the yaw cylinder from serviceable components. (5.2.5d)

f. Given a tandem hydraulic pump used in the MK48 steering system, the required tools, shop supplies, repair parts, and TM 9-2320-297-34, per information contained in the reference:

(1) disassemble the tandem hydraulic pump, (5.2.6a)

(2) inspect the disassembled components for serviceability, (5.2.6b)

(3) repair or replace the unserviceable components, and (5.2.6c)

(4) assemble the tandem hydraulic pump from serviceable components. (5.2.6d)

OUTLINE

1. CONSTRUCTION, NOMENCLATURE AND PRINCIPLES OF OPERATION OF POWER STEERING SYSTEMS

a. Power Steering Pump. The chief function of the power steering pump is to produce the hydraulic pressure needed to provide steering assistance to control the vehicle, regardless of the size of the vehicle. Some pumps also provide pressure for the power brake booster.

b. Steering Gear Function and Primary Assemblies. The chief function of the steering gear is to enable the vehicle operator to control the front wheels, using the hydraulic force developed by the pump. This function is accomplished through the operation of five assemblies: the pitman shaft or output shaft, the rack piston, the worm shaft assembly, the valve assembly and the housing.

(1) Valve assembly components and functions.

(a) The valve spool and body control the flow of fluid from the pump to the rack piston.

(b) The valve spool is connected to the stub shaft or input shaft of the steering gear.

(c) The valve body (or sleeve) is pinned or keyed to the worm shaft and rotates with the worm shaft.

(d) The worm shaft and stub or input shaft are connected together by what is know as a torsion bar, which acts as a centering device for the valve spool and body.

(e) The valve functions as the controlling device for the fluid and sends the fluid to the proper location in the steering system.

(2) Worm shaft assembly.

(a) The worm shaft is threaded through the rack piston and is attached to the control valve.

(b) Between the worm shaft and the piston, there is usually a rolling thread. This means that between the shaft and piston there is a number of single roller bearings which reduce the friction or resistance when the shaft is rotated within the piston.

(3) The rack piston.

(a) The rack piston is grooved (threaded) on the inside to accommodate the worm shaft. It has interior channels through which the ball bearings circulate, acting as a rolling thread between the worm shaft and piston.

(b) The rack piston has a gear or teeth on the outside to mesh with the gear on the pitman shaft or sector shaft.

(c) The rack piston converts the hydraulic pressure into mechanical force. The hydraulic force applied to either end of the rack piston forces the piston to move within the housing.

(4) Pitman or output shaft.

(a) The pitman shaft is the mechanical link between the power steering gear and the steering linkage.

(b) At one end, the pitman shaft is connected to the rack piston by means of a gear (or sector) which meshes with the gear on the piston. The other end is connected to the pitman arm. This ties the steering gear to the linkage.

(5) Steering gear housing.

(a) The steering gear housing contains all of the gear components.

(b) The housing also acts as the power cylinder for the rack piston.

(c) There are drilled passages in the housing which allow the control valve to direct the fluid to the proper location.

(6) Steering gear operation.

(a) When the driver exerts a force on the steering wheel to initiate a turn, the force is transmitted to the steering gear input shaft. The input shaft is connected to the worm shaft by a torsion bar and applies a rotational force to the worm shaft. In response to this force, the worm shaft tries to move the rack piston inside the housing. The piston resists movement due to its engagement with the sector shaft so the torsion bar deflects or twists.

(b) As the torsion bar deflects, it allows the input shaft and spool to rotate slightly within the valve body. This relative rotation actuates the control valve.

(c) As the valve is actuated, the valve passages begin to direct fluid through the valve. This directs a portion of the fluid from the pump to one or the other of the cylinder cavities.

(d) The amount of flow which is directed to the cylinder cavity is proportional to the speed at which the steering wheel is being turned. The pressure required to complete the steering maneuver is dependent on the amount of resistance presented by the steered wheels. The control valve senses these requirements and supplies fluid to the cylinder at the proper flow rate and pressure.

(e) As fluid is supplied to the cylinder, the rack piston moves, rotating the sector or pitman shaft and steering the vehicle. The worm shaft is now able to rotate in response to the force being applied by the torsion bar. Steering action will continue in this manner so long as the driver continues to turn the steering wheel. When the steering maneuver is completed and effort on the steering wheel is relaxed, the torsion bar brings the control valve back to its neutral position.

(f) If the steered wheels are subjected to shock loads, forces are transmitted through the sector or pitman shaft to the rack piston and on to the worm shaft. This actuates the control valve, which directs high pressure fluid to the proper side of the piston to resist the shock load. By absorbing the shock loads hydraulically, kickback at the steering wheel is prevented.

(g) Some steering gears are equipped with unloading valves or poppets in the piston, which trip as the steered wheels reach a full turn and the piston approaches the end of its stroke.

(h) Tripping these unloading valves reduces the pressure in the power cylinder by allowing a portion of the flow from the pump to circulate through the gear and back to the reservoir. Reducing the cylinder pressure decreases the amount of load being carried by the linkage components and the pump drive components. Since fluid is allowed to circulate through the gear, the pressure relief in the pump is not required to activate when the wheels reach a full turn and the amount of heat generated by the pump is greatly reduced.

c. Power Steering Assist Cylinder

(1) The purpose of the power assist cylinder is to receive fluid under pressure from the steering gear and convert it into mechanical force to aid the operator in turning the front wheels.

(2) The power assist cylinder is mounted on the right side of the vehicle. One end is attached to the vehicle suspension and the other end is attached to the ball stud of the steering knuckle arm. Depending on which way the operator turns the steering wheel, fluid is directed to the cylinder and acts against the piston. This force on the piston is transmitted to the steering knuckle arm to aid in steering the wheels. The fluid that is displaced on the other side of the piston is sent back to the steering gear then to the reservoir of the pump.

d. Manual operation of the steering system.

(1) When power fails, the control is bypassed.

(2) The steering wheel will turn the input shaft.

(3) The input shaft will turn the worm shaft after the torsion bar reaches its limit of rotation.

(4) The worm shaft will push or pull the piston in the cylinder.

(5) The rack piston will turn the pitman or sector shaft the same as it did during power operation.

2. CONSTRUCTION, NOMENCLATURE AND PRINCIPLES OF OPERATION OF THE MK48 STEERING SYSTEM

a. Steering System Operation. Steering of the MK48 is accomplished by both mechanical and hydraulic means. Steering starts at the steering wheel and is transmitted through a series of steering shafts and two, ninety degree gear boxes which lead to the steering gear. The steering gear is a conventional, power-assist type. It is connected to a bellcrank by a pitman arm and a drag link. The bellcrank coordinates the steering action of the front axle with two, double-acting yaw cylinders, using a yaw control valve and a mechanical feedback linkage. Hydraulic pressure for the steering system is provided by an engine driven tandem pump, through flow control valves.

b. Hydraulic System Components and Operation

(1) Hydraulic pump.

(a) The pump is a tandem or double gear type pump consisting of two single pumps, each having its own outlet port and sharing a common inlet port and drive shaft. The pump consists of a port section, front and rear covers, an adapter section, two center sections, two drive gears, two driven gears, four wear plates, four seal packs, two shaft seals, and a shaft coupling.

(b) The tandem pump is essentially two single gear pumps united with a port section and shaft coupling. The inlet port is located in the port section and is common to both pumps. Rotation of the drive and driven gears causes the inlet pressure to decrease. Fluid, pushed into the inlet by atmospheric pressure, is carried to the outlet in chambers formed between the gear teeth and the center section. As the gear teeth mesh, the fluid is forced out through the outlet. The interaction of these two gears, which are the only moving parts within the pump, provides a continuous transfer of fluid from inlet to outlet. Changes in pump volume are accomplished by increasing or decreasing center section width, or by increasing or decreasing pump speed. The outlet port of each pump is located opposite of the inlet port.

(c) This pump is made up of two separate sections. One section provides low output and one section provides high output.

1 Hydraulic oil from the low output side of the pump is sent to the priority flow valve. The priority flow valve divides oil between the steering gear and the demand valve. The steering gear has priority and will receive hydraulic oil first. Any hydraulic oil not needed by the steering gear will be sent to the demand valve.

2 Hydraulic oil from the high output side of the pump is sent directly to the demand valve.

(2) Demand valve. The demand valve is a variable flow control valve that divides oil flow to the fan motor and selector valve. The demand valve will increase the amount of oil to the fan motor as engine speed increases.

(3) Selector valve. The selector valve is a push/pull spool valve. An adjustable pressure relief is built into the selector valve to regulate system pressure. When manually operated, the selector valve directs hydraulic pressure to either the hydraulic steering system or the auxiliary hydraulic connectors on the back of the MK48. Hydraulic pressure is available at the back of the MK48 to power the crane, winch, or hydraulic tools.

c. Hydraulic Steering Operation

(1) When the selector valve is in the steering position, hydraulic oil flows through the yaw control valve to the motion control valve. The yaw feedback linkage signals the yaw control valve to direct oil flow either to or away from the yaw cylinders as required.

(2) Operation of the yaw cylinders is also aided by the motion control valve. Since the motion control valve is operator controlled, it prevents motion of the yaw cylinders when the yaw control valve is in the neutral position. This prevents road wander. If hydraulic pressure is lost due to hydraulic system failure or when towing the vehicle, the lack of operator pressure permits the cylinders to move. This lets the rear module trail freely behind the MK48.

(3) All return oil flows back to the reservoir through the hydraulic oil cooler mounted on the radiator. The oil also flows through a six micron screen filter before entering the reservoir. Oil can then be drawn from the reservoir into the hydraulic pump to begin the cycle again.

d. Hydraulic Steering Components

(1) This system incorporates two ninety degree gear boxes. They use bevel gears to change direction of the rotating steering shafts. Like the name implies, they change the power flow direction ninety degrees.

(2) Another feature is the two yaw cylinders. These are double-acting, hydraulic cylinders. Each cylinder pushes or pulls as needed to steer the vehicle.

(3) Steering gear. The steering gear is a built-in steering unit that incorporates an actuating shaft, actuating valve, piston, pinion, and output shaft. The actuating valve is centered within the piston by reversing springs. As the actuating shaft rotates, the actuating valve moves within the piston. High pressure hydraulic oil is then directed to one side of the piston, causing it to move within the bore of the steering gear housing. The output shaft and the pinion gear are engaged to a rack gear machined into one side of the piston. As the piston moves, the output shaft and pitman arm are rotated by the piston. This controls the steering operation.

(4) Yaw control valve.

(a) The yaw control valve is a spool type hydraulic valve. The valve is connected to the bellcrank and the yaw feedback linkage. As the bellcrank moves, the spool shifts. This directs high pressure hydraulic oil to the yaw cylinders. As the trailer becomes centered behind the power unit, the yaw feedback linkage shifts the spool to the center position. In the center position, the yaw cylinders receive no pressure.

(b) Neutral position is obtained when hydraulic oil flows from the valve inlet to the outlet, by the position of the control spool in relation to internal passages. A load centering spring is used to obtain the desired amount of road feel.

(c) Extend or retract. Movement of the steering wheel in either direction is transmitted through mechanical linkage to the control valve ball stud. Movement of the ball stud causes movement of the control spool. Pump oil flow is directed by spool position to either the head end or rod end of the cylinder, causing the cylinder to extend or retract.

Movement of the cylinder will continue as long as the control spool is offset by continued turning of the steering wheel. When the steering wheel stops turning, the control spool stops and the cylinder and valve body move to the center, neutral position, and stop.

3. INTERMEDIATE MAINTENANCE RESPONSIBILITIES RELATIVE TO THE POWER STEERING SYSTEMS

a. The intermediate maintenance mechanic is responsible for repairing or replacing the following components:

(1) hydraulic power cylinders,

(2) steering gears,

(3) power steering pumps,

(4) ninety degree gear boxes,

(5) yaw control valves,

(6) yaw cylinders,

(7) tandem pumps, and

(8) other steering related components.

b. The intermediate maintenance mechanic is also required to make the necessary adjustments to the steering system components.

4. PROCEDURES REQUIRED TO REPAIR THE POWER STEERING SYSTEM COMPONENTS

a. Repair MK48 Steering Gear Assembly

(1) Detailed instructions for repairing the MK48 steering system components are contained in the manuals that were issued to you at the beginning of this block of instruction. Follow those instructions carefully to effect those repair procedures on the training aid steering system components to which you have been assigned.

(2) Have the instructor assigned to your station check your work at each point designated in this student handout.

(3) Refer to TM 9-2320-297-34 (TM 2320-34/13) for the procedures used to perform the repair steps listed. Use the index to locate the instructions in the manual and read the instructions carefully before performing each task.

(4) Remove relief valve plunger.

(5) Remove pinion gear cover.

(6) Remove output shaft.

(7) Remove cylinder head.

(8) Remove bearing cap.

STOP! Notify the instructor.

(9) Remove actuating piston.

(10) Disassemble actuating piston.

(11) Inspect steering gear components.

STOP! Notify the instructor.

(12) Assemble actuating piston.

STOP! Notify the instructor.

(13) Install cylinder head.

(14) Install actuating piston.

STOP! Notify the instructor.

(15) Install output shaft.

(16) Install relief valve plunger.

(17) Install bearing cap.

(18) Install pinion gear housing.

(19) Install relief valve plunger.

STOP! Notify the instructor.

(20) Store the MK48 steering gear and obtain a 90 degree steering box.

d. Repair MK48 Yaw Control Valve

(1) Remove dust cover.

(2) Remove valve body and ball stud housing.

(3) Remove ball stud.

(4) Disassemble spool valve.

(5) Remove check valve.

STOP! Notify the instructor.

(6) Inspect yaw control valve components.

(7) Install check valve.

(8) Assemble spool valve.

STOP! Notify the instructor.

(9) Install valve body and ball stud housing together.

(10) Install ball stud.

STOP! Notify the instructor.

(11) Install dust cover.

STOP! Notify the instructor.

(12) Store the yaw control valve and obtain a yaw cylinder.

e. Repair MK48 Yaw Cylinder

(1) Remove retainer.

(2) Remove rod.

(3) Remove piston and head.

STOP! Notify the instructor.

(4) Inspect yaw cylinder components.

(5) Install piston and head.

(6) Install rod.

(7) Install retainer.

STOP! Notify the instructor.

(8) Store the yaw cylinder and obtain a hydraulic pump.

f. Repair MK48 Tandem Hydraulic Pump

(1) Remove rear cover.

(2) Remove gears.

(3) Remove center section.

(4) Remove adapter section.

(5) Remove gear coupling.

(6) Remove shaft end cover.

(7) Remove gears.

(8) Remove center section.

(9) Remove seals.

(10) Inspect hydraulic pump components

STOP! Notify the instructor.

(11) Install seals.

(12) Install center section.

(13) Install gears.

STOP! Notify the instructor.

(14) Install shaft end cover.

(15) Install adapter section.

(16) Install center section.

(17) Install gears.

STOP! Notify the instructor.

(18) Install rear cover.

STOP! Notify the instructor.

g. Repair the HFB-64 Power Steering Gear

(1) The instructions for the disassembly of the power steering gear are in TM 9-2320-272-34-2. Take some time to read through those procedures to become familiar with the total task. Then, if you have any questions, ask them.

(2) Disassemble the power steering gear.

(a) Position the sector shaft in center of travel.

(b) Remove the trunnion cover.

(c) Remove the side cover and sector shaft.

(d) Remove the side cover from the sector shaft.

(e) Remove the end cover.

(f) Remove the valve housing.

(g) Disassemble the valve housing.

(h) Remove the rack piston.

(i) Disassemble the rack piston.

STOP! Have the instructor check your work.

(3) Inspect the steering gear components as follows:

(a) It is always easier to inspect and repair clean components, so the first thing is to clean all the steering gear components with solvent and then dry them with low pressure compressed air.

(b) If, during the inspection, you see light polished areas on the steering gear components, this indicates normal wear. We will start our inspection with the sector shaft.

1 Inspect the bearing areas and tooth surfaces for wear marks and pitting. If these areas are worn or pitted, the sector shaft will have to be replaced.

2 Inspect the bearing rollers for pitting, scratches, and wear marks. If the bearing rollers are damaged, replace the bearing rollers and the side cover.

3 Inspect the valve housing thrust bearing and the two thrust washers for wear marks and pitting. If these conditions are found, the damaged components must be replaced.

4 Inspect the rack piston teeth and internal grooves for excessive wear. The rack piston must be replaced if excessive wear is found.

5 Inspect the worm shaft for pitting, galling and scuffing. If any of these conditions exist, the worm shaft must be replaced. Also inspect the worm groove for excessive wear. If it is worn, the worm shaft and rack piston must be replaced.

6 Inspect the bores of the gear housing for scoring or damage. If a bore is scored or damaged, replace the gear housing.

STOP! Have the instructor check your work.

(4) Assemble the steering gear.

(a) Assemble the rack piston.

(b) Install the rack piston.

(c) Install the end cover.

(d) Assemble the valve housing.

STOP! Have the instructor check your work.

(e) Install the valve housing. INSTRUCTOR MUST BE PRESENT.

(f) Install the side cover onto the sector shaft.

(g) Center the rack piston into the housing.

STOP! Have the instructor check your work.

(h) Install the sector shaft and side cover.

(i) Install the trunnion cover.

STOP! Have the instructor check your work.

(5) Adjust the steering gear.

(a) Perform the worm shaft travel adjustment.

STOP! Have the instructor check your work.

(b) Perform the sector shaft adjustment. Record measurement for further reference.

STOP! Have the instructor check your work.

(c) Perform the worm shaft preload adjustment.
STOP! Have the instructor check your work.

(d) Secure the steering gear, and obtain a hydraulic cylinder assembly.

h. Repair the Hydraulic Power Cylinder

(1) The instructions for the disassembly of the hydraulic power cylinder are in TM 9-2320-272-34-2. Take some time to read through those procedures to become familiar with the total task. Then, if you have any questions, ask them.

(2) Disassemble the hydraulic power cylinder.

(a) Remove the end plate.

(b) Remove the piston rod assembly.

(c) Disassemble the piston rod assembly.

STOP! Have the instructor check your work.

(3) Inspect the hydraulic cylinder assembly components for serviceability.

(a) Clean all parts with solvent and dry with compressed air.

(b) Inspect to make sure that the cylinder, piston rod, piston assembly, and gland are not scored, bent or broken.

(c) Inspect to make sure that the retaining rings and backup rings are not damaged.

(d) No repairs are to be made on these parts. If the parts are damaged, replace with new ones.

STOP! Have the instructor check your work.

(4) Assemble the power cylinder.

(a) Assemble the piston rod assembly.

(b) Install the piston rod assembly.

(c) Install the end plate.

STOP! Have the instructor check your work.

(d) Secure the hydraulic cylinder, tools, and equipment and return to the classroom.

REFERENCES:

TM 9-2320-272-34-2
TM 9-2320-297-34